

(19) World Intellectual Property Organization
International Bureau



36

(43) International Publication Date
28 November 2002 (28.11.2002)

PCT

(10) International Publication Number
WO 02/094794 A1

(51) International Patent Classification⁷: C07D 233/94,
295/155, 333/20, A61K 31/495, 31/496, A61P 25/04,
25/22

MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG,
SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ,
VN, YU, ZA, ZM, ZW.

(21) International Application Number: PCT/SE02/00956

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(22) International Filing Date: 16 May 2002 (16.05.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0101772-2 18 May 2001 (18.05.2001) SE
0103820-7 15 November 2001 (15.11.2001) SE

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)
- of inventorship (Rule 4.17(iv)) for US only

(71) Applicant (for all designated States except US): AS-TRAZENECA AB [SE/SE]; S-151 85 Södertälje (SE).

(72) Inventors; and

(75) Inventors/Applicants (for US only): BROWN, William [CA/CA]; AstraZeneca R & D Montreal, 7171 Frederick-Banting, St. Laurent, Montreal, Québec H4S 1Z9 (CA). WALPOLE, Christopher [GB/CA]; AstraZeneca R & D Montreal, 7171 Frederick-Banting, St. Laurent, Montreal, Québec H4S 1Z9 (CA). PLOBECK, Niklas [SE/SE]; AstraZeneca R & D Södertälje, S-151 85 Södertälje (SE).

(74) Agent: GLOBAL INTELLECTUAL PROPERTY; AstraZeneca AB, S-151 85 Södertälje (SE).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: 4 (PHENYL-PIPERAZINYL-METHYL) BENZAMIDE DERIVATIVES AND THEIR USE FOR THE TREATMENT OF PAIN ANXIETY OR GASTROINTESTINAL DISORDERS

(57) Abstract: Compounds of general formula I R¹ is selected from any one of phenyl, pyridinyl, thienyl, furanyl, imidazolyl, pyrrolyl, triazolyl, thiazolyl, and pyridine N-oxide; R² is independently selected from ethyl and isopropyl; R³ is independently selected from hydrogen and fluoro; R⁴ is independently selected from -OH, -NH₂ and -NHSO₂R⁵; and R⁵ is independently selected from hydrogen, -CF₃ and C₁-C₆ alkyl, or salts thereof or separate enantiomers and salts thereof; where each R¹ heteroaromatic ring may optionally and independently be further substituted by 1, 2 or 3 substituents selected from straight and branched C₁-C₆ alkyl, NO₂, CF₃, C₁-C₆ alkoxy, chloro, fluoro, bromo, and iodo. The substitutions on the heteroaromatic ring may take place in any position on said ring systems; are disclosed and claimed in the present application, as well as separate enantiomers of the compounds and salts and pharmaceutical compositions comprising the novel compounds and their use in therapy, in particular in the management of pain, anxiety and functional gastrointestinal disorders.

WO 02/094794 A1

4(Phenyl-piperaziny1-methyl) benzamide derivatives and their use for the treatment of pain, anxiety or gastrointestinal disorders.

Field of the Invention

The present invention is directed to novel compounds, to a process for their preparation, their use and pharmaceutical compositions comprising the novel compounds. The novel compounds are useful in therapy, and in particular for the treatment of pain, anxiety and functional gastrointestinal disorders.

Background of the Invention

The δ receptor has been identified as having a role in many bodily functions such as circulatory and pain systems. Ligands for the δ receptor may therefore find potential use as analgesics, and/or as antihypertensive agents. Ligands for the δ receptor have also been shown to possess immunomodulatory activities.

The identification of at least three different populations of opioid receptors (μ , δ and κ) is now well established and all three are apparent in both central and peripheral nervous systems of many species including man. Analgesia has been observed in various animal models when one or more of these receptors has been activated.

With few exceptions, currently available selective opioid δ ligands are peptidic in nature and are unsuitable for administration by systemic routes. One example of a non-peptidic δ -agonist is SNC80 (*Bilsky E.J. et al., Journal of Pharmacology and Experimental Therapeutics*, 273(1), pp. 359-366 (1995)). There is however still a need for selective δ -agonists having not only improved selectivity, but also an improved side-effect profile.

Thus, the problem underlying the present invention was to find new analgesics having improved analgesic effects, but also with an improved side-effect profile over current μ agonists, as well as having improved systemic efficacy.

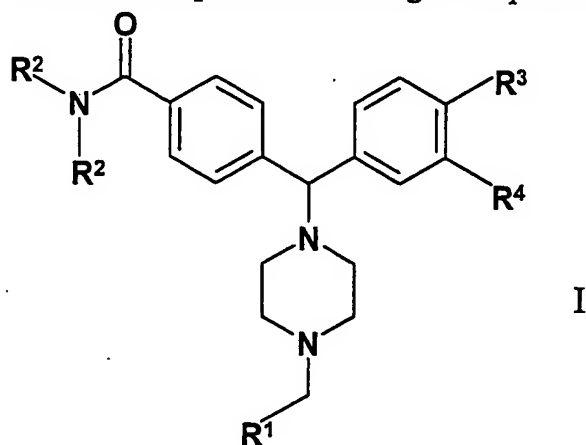
Analgesics that have been identified and are existing in the prior art have many disadvantages in that they suffer from poor pharmacokinetics and are not analgesic when administered by systemic routes. Also, it has been documented that preferred δ agonist compounds, described within the prior art, show significant convulsive effects when
5 administered systemically.

We have now found certain compounds that exhibit surprisingly improved properties, *i.a.* improved δ -agonist potency, in vivo potency, pharmacokinetic, bioavailability, in vitro stability and/or lower toxicity.

10

Outline of the Invention

The novel compounds according to the present invention are defined by the formula I

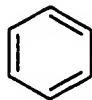


wherein

15

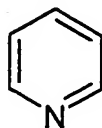
R^1 is selected from any one of

(i) phenyl;

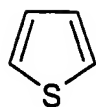


20

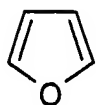
(ii) pyridinyl



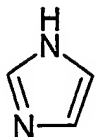
(iii) thienyl



5 (iv) furanyl

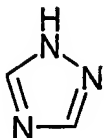


(v) imidazolyl



10

(vi) triazolyl

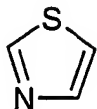


(vii) pyrrolyl

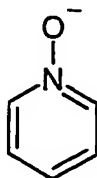


15

(viii) thiazolyl



(ix) pyridyl-N-oxide



20

wherein each R^1 heteroaromatic ring may optionally and independently be further substituted by 1, 2 or 3 substituents selected from straight and branched C_1 - C_6 alkyl, halogenated C_1 - C_6 alkyl, NO_2 , CF_3 , C_1 - C_6 alkoxy, chloro, fluoro, bromo, and iodo;

5 R^2 is independently selected from ethyl and isopropyl;

R^3 is independently selected from hydrogen and fluoro;

R^4 is independently selected from -OH, $-NH_2$ and $-NHSO_2R^5$; and

10

R^5 is independently selected from hydrogen, $-CF_3$ and C_1 - C_6 alkyl, provided that when R^2 is ethyl and R^3 is hydrogen then R^4 cannot be -OH.

15

The substitutions on the heteroaromatic ring may take place in any position on said ring systems.

When the R^1 phenyl ring and the R^1 heteroaromatic ring(s) are substituted, the preferred substituents are selected from any one of CF_3 , methyl, iodo, bromo, fluoro and chloro, of which methyl is most preferred.

20

A further embodiment of the present invention is thus a compound according to formula I wherein R^1 is as defined above and each R^1 phenyl ring and R^1 heteroaromatic ring may independently be further substituted by a methyl group;

25

A further embodiment of the present invention is a compound according to figure I wherein R^1 is phenyl, pyrrolyl, furanyl, thienyl or imidazolyl; R^2 is ethyl or isopropyl; R^3 is hydrogen or fluoro; R^4 is $-NH_2$ or $-NHSO_2R^5$; and R^5 is C_1 - C_6 alkyl, optionally with 1 or 2 of the preferred substituents on the R^1 phenyl or R^1 heteroaromatic ring.

30

An additional embodiment of the present invention is a compound according to figure I wherein R^1 is phenyl, pyrrolyl, furanyl, thienyl or imidazolyl; R^2 is ethyl or isopropyl; R^3 is hydrogen; R^4 is $-NHSO_2R^5$; and R^5 is C_1 - C_6 alkyl, optionally with 1 or 2 of the preferred

substituents on the R¹ phenyl or R¹ heteroaromatic ring.

Other embodiments of the present invention are compounds according to Figure I wherein
a) R¹ is phenyl, pyrrolyl, or furanyl; R² is ethyl or isopropyl; R³ is hydrogen or fluoro; and
5 R⁴ is -NH₂; b) R¹ is thienyl or imidazolyl; R² is ethyl or isopropyl; R³ is hydrogen or
fluoro; and R⁴ is -NH₂; c) R¹ is phenyl, pyrrolyl, furanyl, thienyl or imidazolyl; R² is ethyl
or isopropyl; R³ is hydrogen or fluoro; R⁴ is -NHSO₂R⁵; and R⁵ is C₁-C₆ alkyl; and d) R¹ is
phenyl, pyrrolyl, furanyl, thienyl or imidazolyl; R² is ethyl or isopropyl; R³ is hydrogen or
fluoro; R⁴ is -NHSO₂R⁵; and R⁵ is C₁-C₆ alkyl, wherein all embodiments a) to d) may
10 optionally be substituted with 1 or 2 of the preferred substituents on the R¹ phenyl or R¹
heteroaromatic ring.

Within the scope of the invention are also separate enantiomers and salts of the compounds
of the formula I, including salts of enantiomers. Also within the scope of the present
15 invention are mixtures of the separate enantiomers, such as the racemic mixture, as well
as salts of mixtures of separate enantiomers.

Separation of racemic mixtures into separate enantiomers is well known in the art and may
be accomplished for example by separation on a suitable chiral chromatography column.
20 Preparation of salts is well known in the art, and may be accomplished for example by
mixing a compound of formula I in a suitable solvent with the desired protic acid and
isolation by means standard in the art. Salts of compounds of formula I include
pharmaceutically acceptable salts and also pharmaceutically unacceptable salts.

25 The novel compounds of the present invention are useful in therapy, especially for the
treatment of various pain conditions such as chronic pain, neuropathic pain, acute pain,
cancer pain, pain caused by rheumatoid arthritis, migraine, visceral pain etc. This list
should however not be interpreted as exhaustive.

Compounds of the invention are useful as immunomodulators, especially for autoimmune diseases, such as arthritis, for skin grafts, organ transplants and similar surgical needs, for collagen diseases, various allergies, for use as anti-tumour agents and anti viral agents.

- 5 Compounds of the invention are useful in disease states where degeneration or dysfunction of opioid receptors is present or implicated in that paradigm. This may involve the use of isotopically labelled versions of the compounds of the invention in diagnostic techniques and imaging applications such as positron emission tomography (PET).
- 10 Compounds of the invention are useful for the treatment of diarrhoea, depression, anxiety and stress-related disorders such as post-traumatic stress disorders, panic disorder, generalized anxiety disorder, social phobia, and obsessive compulsive disorder; urinary incontinence, various mental illnesses, cough, lung oedema, various gastro-intestinal disorders, e.g. constipation, functional gastrointestinal disorders such as Irritable Bowel
- 15 Syndrome and Functional Dyspepsia, Parkinson's disease and other motor disorders, traumatic brain injury, stroke, cardioprotection following myocardial infarction, spinal injury and drug addiction, including the treatment of alcohol, nicotine, opioid and other drug abuse and for disorders of the sympathetic nervous system for example hypertension.
- 20 Compounds of the invention are useful as an analgesic agent for use during general anaesthesia and monitored anaesthesia care. Combinations of agents with different properties are often used to achieve a balance of effects needed to maintain the anaesthetic state (e.g. amnesia, analgesia, muscle relaxation and sedation). Included in this combination are inhaled anaesthetics, hypnotics, anxiolytics, neuromuscular blockers and
- 25 opioids.

Also within the scope of the invention is the use of any of the compounds according to the formula I above, for the manufacture of a medicament for the treatment of any of the conditions discussed above.

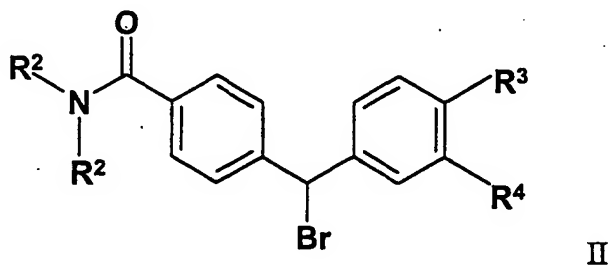
A further aspect of the invention is a method for the treatment of a subject suffering from any of the conditions discussed above, whereby an effective amount of a compound according to the formula I above, is administered to a patient in need of such treatment.

5 Methods of preparation

The compounds of the present invention can be prepared using the following general procedure.

10 Preparation of Phenols; Examples 1-3

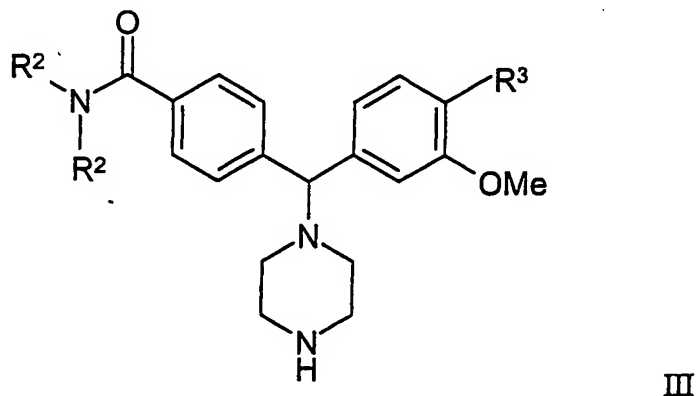
The compounds of formula I wherein R^4 is $-OH$ is prepared by reacting a compound of the general formula II



15

wherein R^2 and R^3 are as defined in Figure 1 and R^4 is OMe, with Boc-piperazine in acetonitrile in the presence of triethylamine under standard conditions, followed by removal of the Boc protection group under standard conditions to give a compound of the Formula III

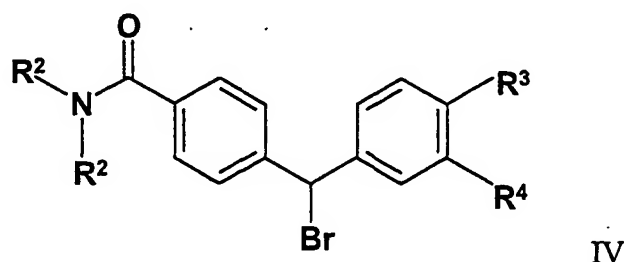
20



which is thereafter alkylated under reductive conditions with a compound of the Formula R^1 -CHO, followed by cleavage of the methyl ether using BBr_3 in dichloromethane to give a compound of the Formula I wherein R^4 is $-OH$.

5 Preparation of Anilines; Examples 4-6

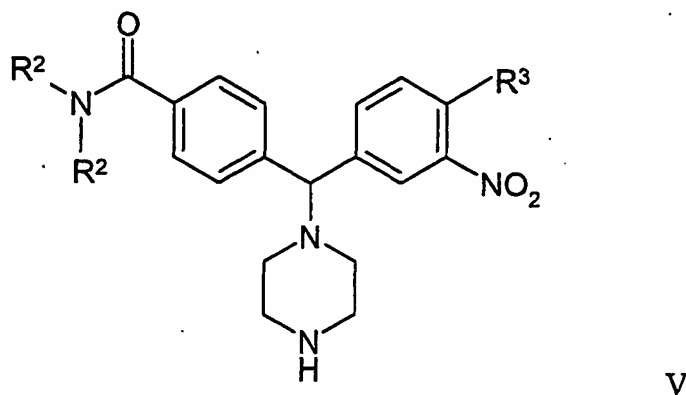
The compound of formula I wherein R^4 is $-NH_2$ is prepared by reacting a compound of the general formula IV



10

wherein R^2 and R^3 are as defined in Figure 1 and R^4 is NO_2 , with Boc-piperazine in acetonitrile in the presence of triethylamine under standard conditions, followed by removal of the Boc protection group under standard conditions to give a compound of the Formula V

15

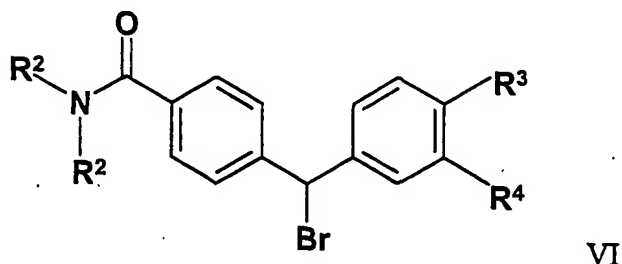


which is thereafter alkylated under reductive conditions with a compound of the Formula R^1 -CHO, followed by reduction of the nitro group using hydrogen and palladium on charcoal to give a compound of the Formula I wherein R^4 is $-NH_2$.

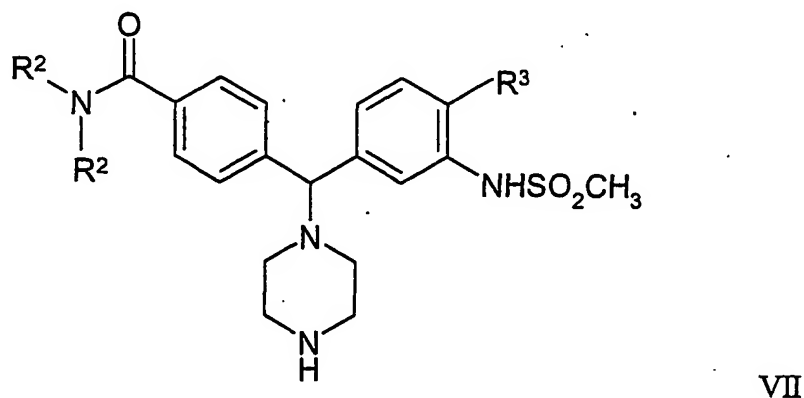
20

Preparation of Methyl Sulfonanilides; Examples 7-8

The compound of formula I wherein R^4 is $-NHSO_2R^5$ is prepared by reacting a compound of the general formula VI



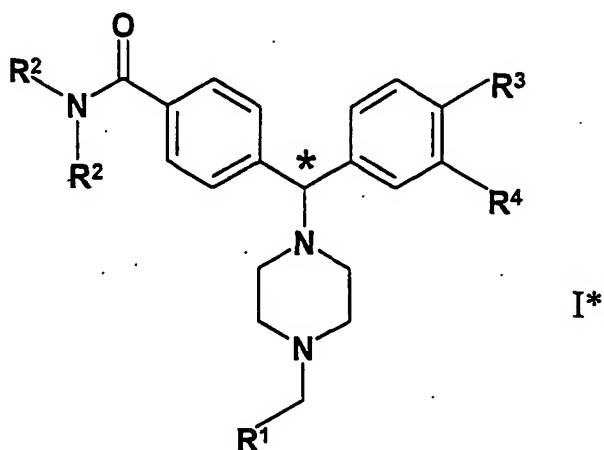
wherein R^2 and R^3 are as defined in claim 1 and R^4 is NO_2 , with Boc-piperazine in acetonitrile in the presence of triethylamine under standard conditions, followed reduction of the nitro group by hydrogenolysis using palladium on charcoal as the catalyst,
 10 metanesulphonylation using methanesulphonylanhydride in dichloromethane in the presence of triethylamine, and thereafter removal of the Boc protection group under standard conditions to give a compound of the Formula VII



15 which is thereafter alkylated under reductive conditions with a compound of the Formula R^1-CHO , followed by reduction of the nitro group using hydrogen and palladium on charcoal to give a compound of the Formula I wherein R^4 is $-NHSO_2R^5$.

20 Within the scope of the invention are also separate enantiomers and salts of the compounds of the Formula I, including salts of enantiomers. Compounds of Formula I are chiral

compounds, with the diarylmethylpiperazine group being the stereogenic center, see Figure I* below.



- 5 A further embodiment of the present invention is thus the (-)-enantiomer of a compound according to Formula I, as well as a salt of said compound.

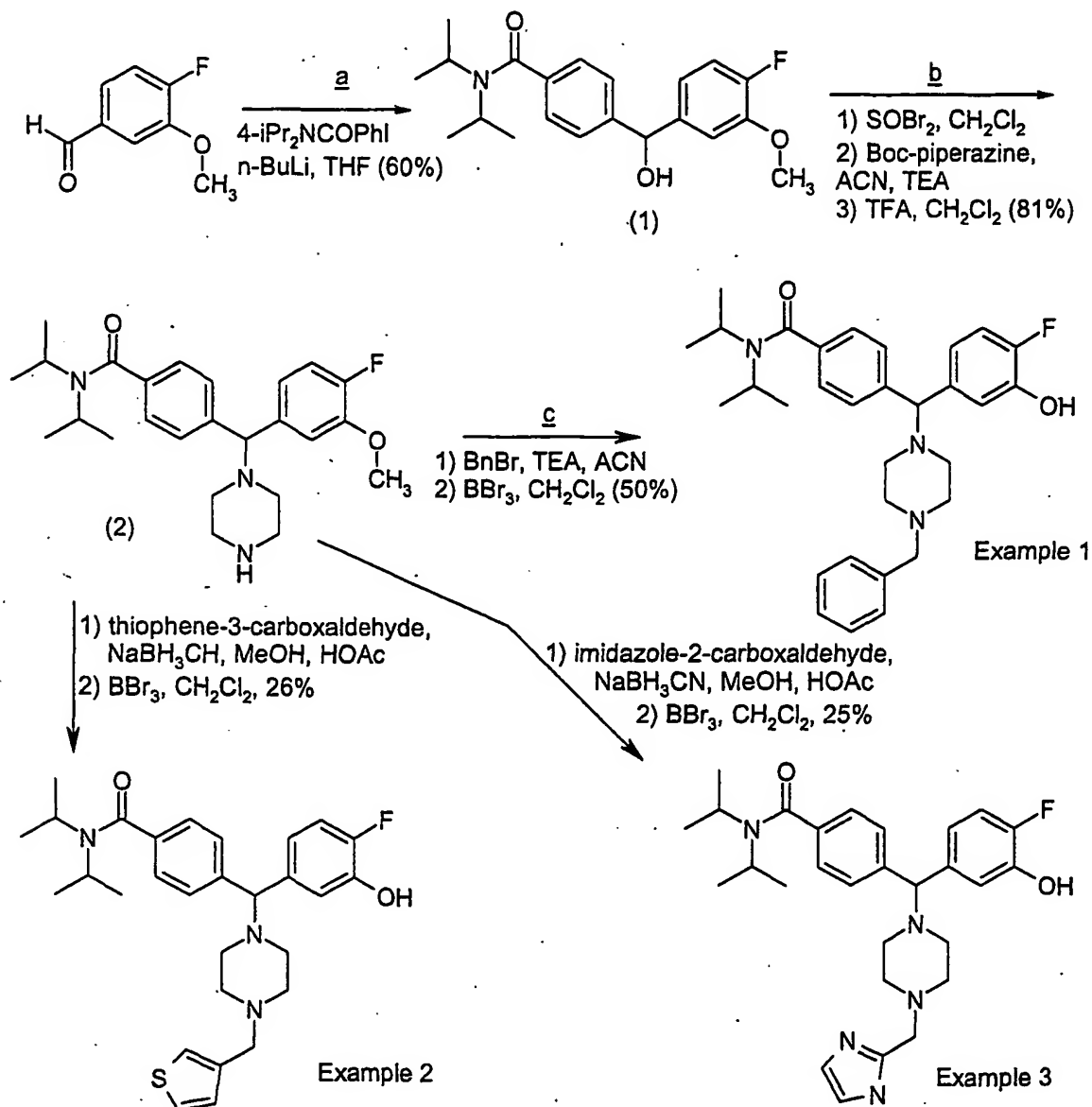
A further embodiment of the present invention is thus the (+)-enantiomer of a compound according to Formula I, as well as a salt of said compound.

10

EXAMPLES

The invention will now be described in more detail by the following Examples, which are not to be construed as limiting the invention.

Scheme 1: Preparation of Fluoro Phenols; Examples 1-3



Intermediate 1: 4-[(4-fluoro-3-methoxyphenyl)(hydroxy)methyl]-*N,N*-diisopropylbenzamide.

- 5 *N,N*-Diisopropyl-4-iodobenzamide (6.0 g, 18 mmol) was dissolved in THF (200 mL) and cooled to -78°C under nitrogen atmosphere. $n\text{-BuLi}$ (14 mL, 1.3 M solution in hexane, 18 mmol) was added dropwise during 10 min at -65 to -78°C . 4-fluoro-3-methoxybenzaldehyde (2.8 g, 18 mmol) was added dropwise dissolved in THF (5 mL). NH_4Cl (aq.) was added after 30 min. After concentration *in vacuo*, extraction with EtOAc /
- 10 water, drying (MgSO_4) and evaporation of the organic phase, the residue was purified by chromatography on silica (0 – 75% EtOAc/heptane) to yield the desired product (3.9 g,

60%). ^1H NMR (CDCl_3) δ 1.0-1.6 (m, 12H), 2.65 (d, $J = 4\text{Hz}$, 1H), 3.4-3.9 (m, 2H), 3.80 (s, 3H), 6.10 (d, $J = 4\text{Hz}$, 1H), 6.76 (m, 1H), 6.95 (m, 1H), 7.04 (m, 1H), 6.76 (m, 1H), 7.25, 7.40 (2d, $J = 7.5\text{Hz}$, 4H).

5 Intermediate 2: 4-[(4-fluoro-3-methoxyphenyl)(1-piperazinyl)methyl]-*N,N*-diisopropylbenzamide.

Intermediate 1 (3.9 g, 11 mmol) was dissolved in dry CH_2Cl_2 (50 mL) and treated with SOBr_2 (0.88 mL, 11 mmol) at 0 to 25 °C for 30 min. Neutralization with KHCO_4 (aq.) and drying (K_2CO_4) of the organic phase was followed by solvent evaporation *in vacuo*. The residue and Et_3N (1.8 mL, 13 mmol) was dissolved in MeCN (50 mL) and stirred with Boc-piperazine (2.1 g, 11 mmol) at 25 °C for 12 h. Concentration *in vacuo* and chromatography on silica (0 to 50% EtOAc in heptane) gave 4.6g. 1.6g was treated with TFA in CH_2Cl_2 (1:1), concentrated *in vacuo*, extracted CH_2Cl_2 / K_2CO_4 (aq.), dried (K_2CO_4) and evaporated *in vacuo* to give Intermediate 2 (1.3 g, 81% from intermediate 1).
15 MS (ES) 428.21 (MH+).

Example 1: 4-[1-(4-Benzyl-piperazin-1-yl)-1-(4-fluoro-3-hydroxy-phenyl)-methyl]-*N,N*-diisopropyl-benzamide.

Intermediate 2 (0.41 g, 0.96 mmol) and triethylamine (0.20 mL, 1.4 mmol) were dissolved in MeCN (10 mL). Benzyl bromide (0.14 mL, 1.1 mmol) was added with stirring at 25 °C. After 12 h the solution was concentrated and purified by reverse phase chromatography (LiChroprep RP-18, 10-80 % MeCN in water, 0.1 % TFA). 0.53 g of free base was obtained after extraction with CH_2Cl_2 / K_2CO_4 (aq.), drying (K_2CO_4) and evaporation *in vacuo*. Treatment with boron tribromide (4 eq., 1M solution in CH_2Cl_2) in CH_2Cl_2 at -78 °C, addition of water, concentration *in vacuo* and reverse phase chromatography gave Example 1 as the trifluoroacetate (0.35 g, 50%). MS (ES) 504.22 (MH+). IR (NaCl) 3222, 1677, 1592, 1454, 1346, 1201, 1135 (cm^{-1}). ^1H NMR (CD_3OD) δ = 1.1, 1.5 (m, 12H), 2.3 (m, 3H), 2.9-3.8 (m, 7H), 4.33 (s, 2H), 4.75 (s, 1H), 6.60 (m, 1H), 6.83 (m, 1H), 6.94 (m, 1H), 7.24 (d, $J = 8\text{Hz}$, 2H), 7.47 (m, 7H). Anal. Calc. for $\text{C}_{31}\text{H}_{38}\text{FN}_3\text{O}_2 \cdot 0.8\text{C}_4\text{H}_2\text{F}_6\text{O}_4$
25 C:59.87, H:5.82, N:6.12. Found C:60.06, H:5.83, N:6.19.
30

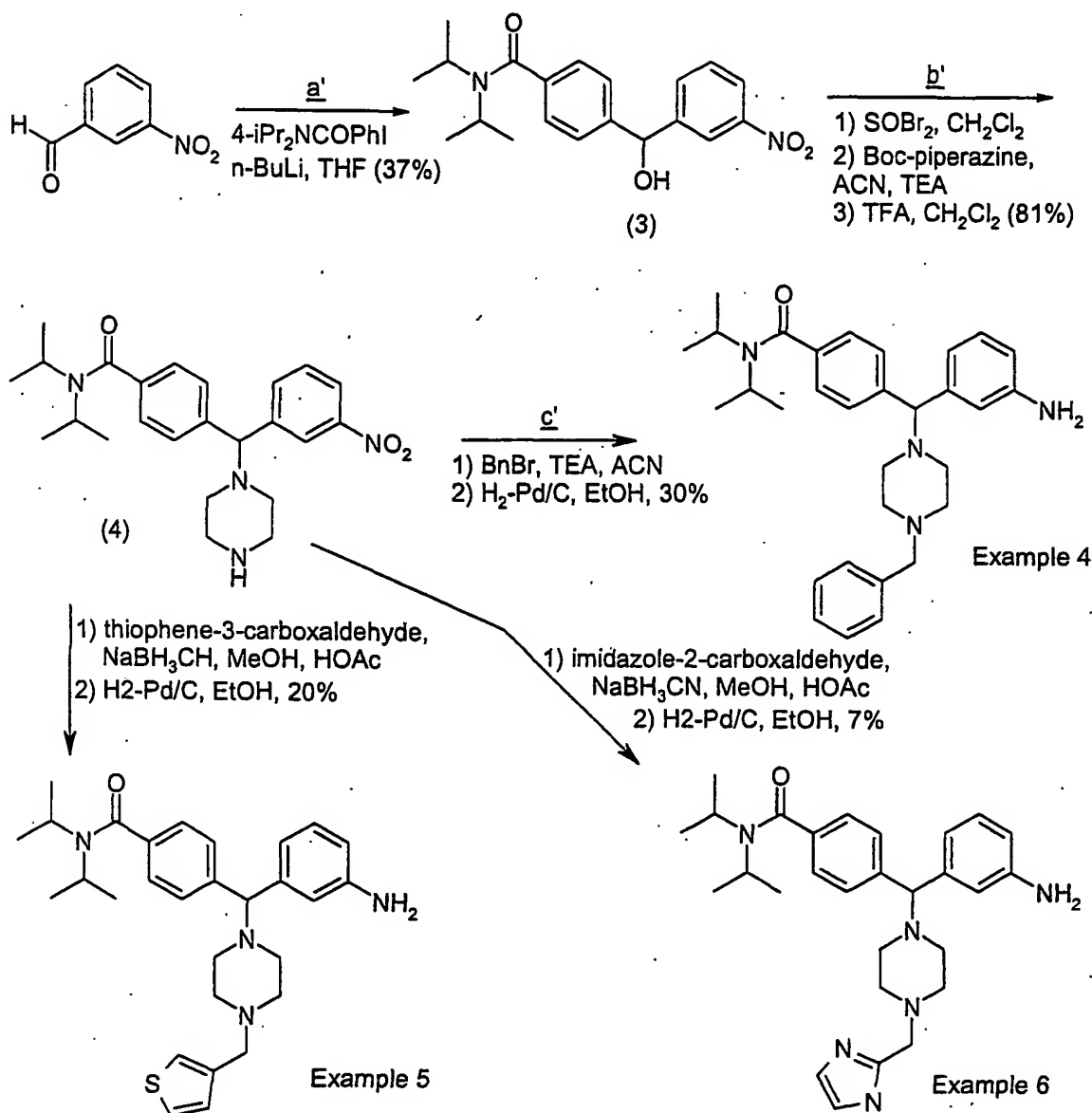
Example 2: 4-[1-(4-Fluoro-3-hydroxy-phenyl)-1-(4-thiophen-3-ylmethyl-piperazin-1-yl)-methyl]-N,N-diisopropyl-benzamide.

Intermediate 2 (0.43 g, 1.0 mmol) was dissolved in MeOH (5 mL) with 3-thiophene-carboxaldehyde (0.11 mL, 1.2 mmol) and HOAc (57 μ L, 1.0 mmol) and stirred for 1 h. Sodium cyanoborohydride (63 mg, 1.0 mmol) was added in portions over 6 h and the reaction was stirred at 25 °C for an additional 12 h before working up by concentration *in vacuo* and extraction (CH_2Cl_2 / $\text{K}_2\text{CO}_3(\text{aq})$). Purification by reverse phase chromatography as for Example 1 to give 0.32 g (0.62 mmol) as free base. Treatment with boron tribromide as for Example 1 and chromatography gave Example 2 (0.20 g, 26%) as the trifluoroacetate. MS (ES) 510.17 (MH⁺). IR (NaCl) 3281, 1674, 1606, 1454, 1346, 1200, 1135 (cm⁻¹). ¹H NMR (CD_3OD) δ = 1.1, 1.5 (m, 12H), 2.30 (m, 2H), 2.9-3.7 (m, 10H), 4.37 (s, 2H), 4.75 (s, 1H), 6.60 (m, 1H), 6.84 (m, 1H), 6.94 (m, 1H), 7.18 (m, 1H), 7.25, 7.48 (2d, J = 8.0Hz, 4H), 7.55 (m, 1H), 7.65 (m, 1H). Anal. Calc. for $\text{C}_{29}\text{H}_{36}\text{FN}_3\text{O}_2\text{S} \times 0.8 \text{ C}_4\text{H}_2\text{F}_6\text{O}_4 \times 0.5 \text{ H}_2\text{O}$, C:55.16, H:5.55, N:5.99. Found, C:55.12, H:5.39, N:6.07.

Example 3: 4-{1-(4-Fluoro-3-hydroxy-phenyl)-1-[4-(1H-imidazol-2-ylmethyl)-piperazin-1-yl]-methyl}-N,N-diisopropyl-benzamide.

Employing the same procedure as for Example 2 reaction with 2-imidazole-carboxaldehyde (0.10 g, 1.1 mmol) followed by treatment with boron tribromide (6 eq.) gave Example 3 (0.18 g, 25%) as the trifluoroacetate. MS (ES) 494.23 (MH⁺). IR (NaCl) 3123, 1673, 1592, 1454, 1350, 1201, 1135 (cm⁻¹). ¹H NMR (CD_3OD) δ = 1.1, 1.5 (m, 12H), 2.7-3.8 (m, 10H), 3.95 (s, 2H), 5.20 (m, 1H), 6.70 (m, 1H), 6.94 (m, 1H), 7.02 (m, 1H), 7.32, 7.58 (2d, J = 8.0Hz, 4H), 7.46 (s, 1H). Anal. Calc. for $\text{C}_{28}\text{H}_{36}\text{FN}_5\text{O}_2 \times 1.2 \text{ C}_4\text{H}_2\text{F}_6\text{O}_4 \times 0.7 \text{ H}_2\text{O}$, C:50.51, H:5.14, N:8.98. Found, C:50.44, H:5.18, N:9.11.

Scheme 2: Preparation of Anilines; Examples 4-6

Intermediate 3: 4-[hydroxy(3-nitrophenyl)methyl]-N,N-diisopropylbenzamide.

Procedure as for intermediate 1 but after addition of $n\text{-BuLi}$ the solution was cannulated into a solution of 3-nitrobenzaldehyde (2.7 g, 18 mmol) in toluene/THF (approx. 1:1, 100 mL) at -78°C . Workup and chromatography gave for intermediate 3 (2.4 g, 37%). ^1H NMR (CDCl_3) δ 1.1-1.7 (m, 12H), 3.90 (d, $J = 3.5$ Hz, 1H), 3.4-3.9 (m, 2H), 5.91 (s, $J = 3.5$ Hz, 1H), 7.27, 7.35 (2d, $J = 8$ Hz; 4H), 7.51 (m, 1H), 7.71 (m, 1H), 8.13 (m, 1H), 8.30 (s, 1H).

Intermediate 4: N,N-diisopropyl-4-[(3-nitrophenyl)(1-piperazinyl)methyl]benzamide.

Employing the same procedure as for intermediate 2, intermediate 3 (2.4 g, 6.7 mmol) gave Boc-protected intermediate 4 (2.83 g, 81%). TFA treatment quantitatively gave intermediate 4, MS (ES) 425.23 (MH^+).

Example 4: 4-[1-(3-Amino-phenyl)-1-(4-benzyl-piperazin-1-yl)-methyl]-N,N-diisopropyl-benzamide.

Reaction of 7 (0.40 g, 0.94 mmol) with benzyl bromide as for Example 1 was followed by hydrogenation (H₂, 40 psi) with 10% Pd/C (50 mg) in EtOH (25 mL) and 2 N HCl (1.2 mL, 2.4 mmol) for 2 h. Purification by reverse phase chromatography using the same conditions as for Example 1 gave Example 4 (0.20 g, 30%) as the trifluoroacetate. MS (ES) 485.40 (MH⁺). IR (NaCl) 3414, 1673, 1605, 1455, 1345, 1201, 1134 (cm⁻¹). ¹H NMR (CD₃OD) δ = 1.1, 1.5 (m, 12H), 2.3 (m, 2H), 2.9-3.8 (m, 8H), 4.31 (s, 2H), 4.47 (s, 1H), 7.02 (m, 1H), 7.21-7.52 (m, 12H). Anal. Calc. for C₃₁H₄₀N₄O x1.2 C₄H₂F₆O₄ x0.5 H₂O, C:56.04, H:5.70, N:7.30. Found, C:56.06, H:5.67, N:7.41.

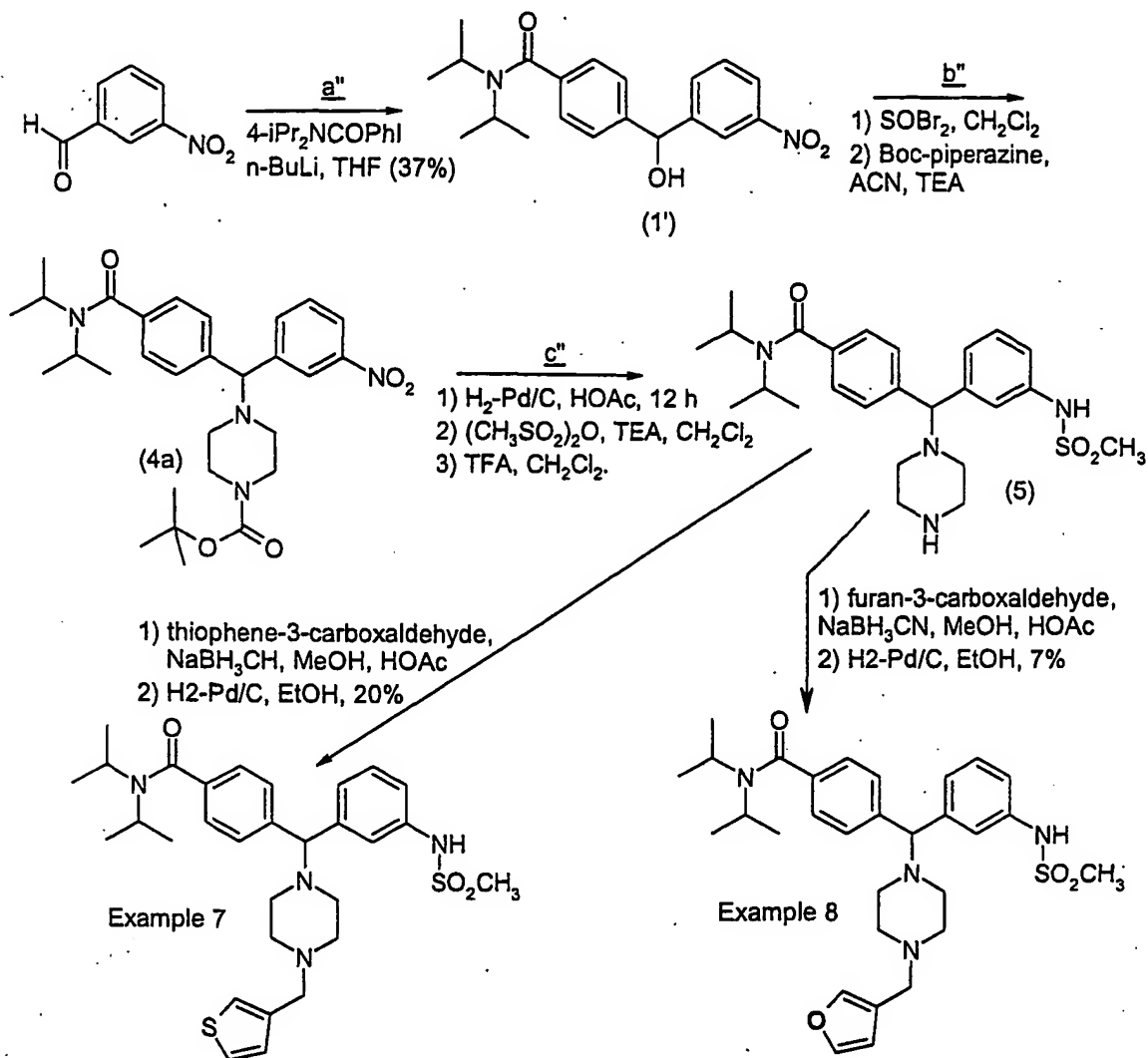
Example 5: 4-[1-(3-Amino-phenyl)-1-(4-thiophen-3-ylmethyl-piperazin-1-yl)-methyl]-N,N-diisopropyl-benzamide.

Reaction of intermediate 4 (0.40 g, 0.94 mmol) with 3-thiophene-carboxaldehyde as for example 2 was followed by hydrogenation (H₂, 30 psi) with 10% Pd/C (50 mg) in EtOH (25 mL) and 2 N HCl (1.0 mL, 2.0 mmol) for 12 h. Purification by reverse phase chromatography using the same conditions as for Example 1 gave Example 5 (0.13 g, 20%) as the ditrifluoroacetate. MS (ES) 491.28 (MH⁺). IR (NaCl) 3408, 1673, 1605, 1455, 1345, 1201, 1134 (cm⁻¹). ¹H NMR (CD₃OD) δ = 1.1, 1.5 (m, 12H), 2.3 (m, 2H), 2.9-3.8 (m, 8H), 4.35 (s, 2H), 4.44 (s, 1H), 6.98 (m, 1H), 7.16-7.32 (m, 6H), 7.49 (d, J = 8Hz, 2H), 7.55 (m, 1H), 7.64 (m, 1H). Anal. Calc. for C₂₉H₃₈N₄OS x1.3 C₄H₂F₆O₄ x0.6 H₂O, C:51.48, H:5.28, N:7.02. Found, C:51.51, H:5.20, N:7.01.

Example 6: 4-{1-(3-Amino-phenyl)-1-[4-(1H-imidazol-2-ylmethyl)-piperazin-1-yl]-methyl}-N,N-diisopropyl-benzamide.

Employing the same procedure as for Example 2, reaction of intermediate 4 with 2-imidazole-carboxaldehyde (0.10 g, 1.1 mmol) followed by hydrogenation gave Example 6 (45 mg, 7%) as ditrifluoroacetate salt. MS (ES) 475.30 (MH⁺). IR (2x TFA, NaCl) 3351, 1674, 1621, 1455, 1349, 1202, 1134 (cm⁻¹). ¹H NMR (2x TFA, CD₃OD) δ = 1.1, 1.5 (m, 12H), 2.9-3.8 (m, 8H), 4.35 (s, 2H), 4.44 (s, 1H), 6.98 (m, 1H), 7.16-7.32 (m, 6H), 7.49 (d, J = 8Hz, 2H), 7.55 (m, 1H), 7.64 (m, 1H). Anal. Calc. for C₂₈H₃₈N₆O x1.6 C₄H₂F₆O₄ x0.8 H₂O, C:48.39, H:5.05, N:9.84. Found, C:48.43, H:5.06, N:9.85.

Scheme 3: Preparation of Methyl Sulfonanilides; Examples 7-8



Intermediate 5: *N,N*-diisopropyl-4-[(3-[(methylsulfonyl)amino]phenyl)(1-piperazinyl)methyl]benzamide.

- Intermediate 3 gave Boc-protected Intermediate 4 as described for Intermediate 4, above. Boc-protected Intermediate 4 (1.21 g, 2.3 mmol) was hydrogenated under H_2 at 30 psi with 10% Pd/C (150 mg) in AcOH (25 mL) for 12 h. Evaporation *in vacuo* and extraction with $\text{CH}_2\text{Cl}_2/\text{K}_2\text{CO}_4$ (aq.) gave 1.1 g (2.3 mmol) of the intermediate aniline, which was dissolved in MeCN/ CH_2Cl_2 (1:1, 10 mL). Et_3N (0.48 mL, 3.4 mmol), then
- methanesulfonylanhydride (0.41 g, 2.4 mmol) was added at 0 °C. After warming to room temperature the reaction was worked up by extraction CH_2Cl_2 /brine. Purification by chromatography on silica (0 – 5% MeOH/ CH_2Cl_2) gave Boc-protected Intermediate 5 (1.3 g, 97%). Treatment with TFA in CH_2Cl_2 quantitatively gave Intermediate 5. MS (ES) 473.16 (MH⁺).

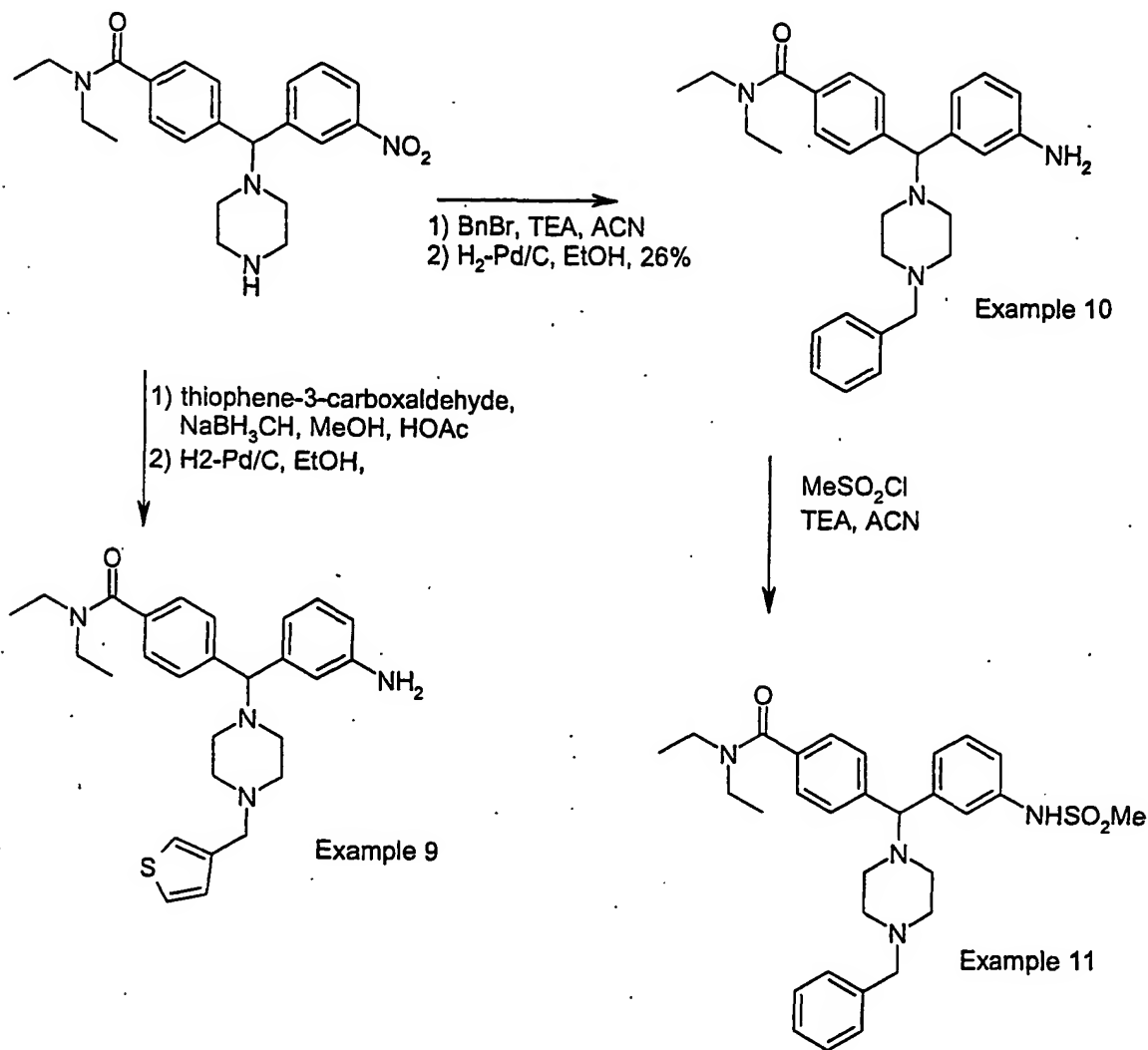
Example 7: *N,N*-Diisopropyl-4-[1-(3-methanesulfonylamino-phenyl)-1-(4-thiophen-3-ylmethyl-piperazin-1-yl)-methyl]-benzamide.

Reductive amination procedure as for Example 2. Intermediate 5 (0.20 g, 0.43 mmol) gave
5 Example 7 (90 mg, 26%) as ditrifluoroacetate salt. The dihydrochloride salt was obtained
after extraction of the free base with $\text{CH}_2\text{Cl}_2/\text{K}_2\text{CO}_4$ (aq.) and treatment with 2 eq. HCl
(aq.). MS (ES) 569.21 (MH⁺). IR (free base, NaCl) 1604, 1455, 1340, 1151 (cm⁻¹). ¹H
NMR (free base, CDCl_3) δ = 0.9- 1.7 (m, 12H), 2.5 (m, 8H), 2.85 (s, 3H), 3.55 (s, 2H), 3.8
(m, 2H), 4.22 (s, 1H), 7.00-7.40 (m, 12H). Anal. Calc. for $\text{C}_{30}\text{H}_{40}\text{N}_4\text{O}_3\text{S}_2 \times 2.6 \text{ HCl}$,
10 C:54.30, H:6.47, N:8.44. Found, C:54.33, H:6.20, N:8.32.

Example 8: 4-([4-(3-furylmethyl)-1-piperazinyl]{3-[(methylsulfonyl)amino]phenyl})-*N,N*-diisopropyl-benzamide.

Employing the same procedure as for Intermediate 7. Intermediate 5 (0.21 g, 0.45 mmol)
15 gave Example 8 (80 mg, 32%) as free base. MS (ES) 553.23 (MH⁺). IR (free base, NaCl)
1604, 1455, 1340, 1151 (cm⁻¹). ¹H NMR (free base, CDCl_3) δ = 1.0- 2.6 (m, 20H), 2.91 (s,
3H), 3.40 (s, 2H), 4.22 (s, 1H), 6.39 (s, 1H), 7.06-7.42 (m, 11H). Anal. Calc. for
 $\text{C}_{30}\text{H}_{40}\text{N}_4\text{O}_4\text{S} \times 2.8 \text{ HCl}$, C:55.03, H:6.59, N:8.56. Found, C:54.93, H:5.93, N:8.49.

Scheme 4: Preparation of Examples 9-11



Example 9: 4-[(3-aminophenyl)[4-(3-thienylmethyl)-1-piperazinyl]methyl]-N,N-diethylbenzamide. N,N-diethyl-4-[(3-nitrophenyl)(1-piperazinyl)methyl]benzamide

(prepared analogous to intermediate (4) in Scheme 2) (0.85 g, 2.1 mmol) was dissolved in MeOH (5 mL) with 3-thiophenecarboxaldehyde (0.40 mL, 4.3 mmol) and HOAc (60 μL , 1.0 mmol) and stirred for 1 h. Sodium cyanoborohydride (135 mg, 2.1 mmol) was added in portions over 6 h and the reaction was stirred at 25 °C for an additional 12 h before working up by concentration *in vacuo* and extraction (CH_2Cl_2 / K_2CO_3 (aq)). Purification by chromatography on silica gave the 3-thienylmethyl derivative (0.45 g, 43%).

Hydrogenation of the product (0.30 g, 0.61 mmol) and reverse phase chromatography gave the title compound (0.17 g, 35%) as the tris-trifluoroacetate. MS (ES) 463.34 (MH^+). IR (NaCl) 3418, 1673, 1600, 1461, 1200, 1135 (cm^{-1}). ^1H NMR (CD_3OD) δ = 1.17, 1.31 (m,

6H), 2.45 (m, 2H), 3.11 (m, 2H), 3.24-3.66 (m, 10H), 4.47 (s, 2H), 4.62 (s, 1H), 7.21 (m, 1H), 7.31 (m, 1H), 7.39-7.56 (m, 5H), 7.61-7.68 (m, 3H), 7.77 (m, 1H).

Example 10: 4-[(3-aminophenyl)(4-benzyl-1-piperazinyl)methyl]-N,N-diethylbenzamide.

5 *N,N*-diethyl-4-[(3-nitrophenyl)(1-piperazinyl)methyl]benzamide (1.7g g, 4.3 mmol) and triethylamine (1.2 mL, 8.6 mmol) was dissolved in MeCN (10 mL). Benzyl bromide (0.56 mL, 4.7 mmol) was added with stirring at 25 °C. After 12 h the solution was concentrated *in vacuo*. Extraction (CH₂Cl₂ /K₂CO₃(aq)) and purification by chromatography on silica gave the benzylated product (1.4 g, 2.9 mmol). Hydrogenation (H₂, 40 psi) with 10% Pd/C
10 (100 mg) in EtOH (25 mL) and 2 N HCl (2.5 mL, 5 mmol) for 4 h was followed by concentration *in vacuo* and reverse phase chromatography to give the title compound as the tris-trifluoroacetate (0.9 g, 26%). MS (ES) 457.26 (MH⁺). IR (NaCl) 3422, 1672, 1603, 1458, 1209, 1133 (cm⁻¹). ¹H NMR (CD₃OD) δ = 1.1, 1.2 (m, 6H), 2.3 (m, 2H), 2.9-3.6 (m, 10H), 4.33 (s, 2H), 4.49 (s, 1H), 5.48 (s, 2H), 7.01 (m, 1H), 7.24-7.34 (m, 5H), 7.47 (m,
15 5H), 7.52 (d, J = 7.5 Hz, 2H).

Example 11: 4-((4-benzyl-1-piperazinyl){3-[(methylsulfonyl)amino]phenyl}methyl)-N,N-diethylbenzamide. The product of Example 10 (0.35 g, 0.76 mmol) and triethylamine (0.12 mL, 0.84 mmol) was dissolved in MeCN (10 mL) and methanesulfonic anhydride (0.14 g,
20 0.84 mmol) was added at 0°C. After stirring 10 min at 25°C, the solution was concentrated *in vacuo* and purified by reverse phase chromatography to give the title compound as the bis-trifluoroacetate (0.23 g, 40%). MS (ES) 535.21 (MH⁺). IR (NaCl) 3479, 1673, 1604, 1458, 1337, 1200, 1150 (cm⁻¹). ¹H NMR (CD₃OD) δ = 1.18, 1.31 (m, 6H), 2.41 (m, 2H), 2.98 (s, 3H), 3.13 (m, 2H), 3.28-3.65 (m, 8H), 4.44 (s, 2H), 4.57 (s, 1H), 5.57 (d, J=2Hz,
25 2H), 7.15 (m, 1H), 7.30 (m, 1H), 7.37 (m, 1H), 7.42 (m, 2H), 7.54-7.60 (m, 6H), 7.63 (m, 2H).

Pharmaceutical compositions

30 The novel compounds according to the present invention may be administered orally, intramuscularly, subcutaneously, topically, intranasally, intraperitoneally, intrathoracically,

intravenously, epidurally, intrathecally, intracerebroventricularly and by injection into the joints.

A preferred route of administration is orally, intravenously or intramuscularly.

5

The dosage will depend on the route of administration, the severity of the disease, age and weight of the patient and other factors normally considered by the attending physician, when determining the individual regimen and dosage level as the most appropriate for a particular patient.

10

For preparing pharmaceutical compositions from the compounds of this invention, inert, pharmaceutically acceptable carriers can be either solid or liquid. Solid form preparations include powders, tablets, dispersible granules, capsules, cachets, and suppositories.

15

A solid carrier can be one or more substances which may also act as diluents, flavoring agents, solubilizers, lubricants, suspending agents, binders, or tablet disintegrating agents; it can also be an encapsulating material.

20

In powders, the carrier is a finely divided solid which is in a mixture with the finely divided active component. In tablets, the active component is mixed with the carrier having the necessary binding properties in suitable proportions and compacted in the shape and size desired.

25

For preparing suppository compositions, a low-melting wax such as a mixture of fatty acid glycerides and cocoa butter is first melted and the active ingredient is dispersed therein by, for example, stirring. The molten homogeneous mixture is then poured into convenient sized molds and allowed to cool and solidify.

30

Suitable carriers are magnesium carbonate, magnesium stearate, talc, lactose, sugar, pectin, dextrin, starch, tragacanth, methyl cellulose, sodium carboxymethyl cellulose, a low-melting wax, cocoa butter, and the like.

Salts include, but are not limited to pharmaceutically acceptable salts. Examples of pharmaceutically acceptable salts within the scope of the present invention include: acetate, benzenesulfonate, benzoate, bicarbonate, bitartrate, bromide, calcium acetate, camsylate, carbonate, chloride, citrate, dihydrochloride, edetate, edisylate, estolate, esylate, fumarate, glucaptate, gluconate, glutamate, glycolylarsanilate, hexylresorcinate, hydrabamine, hydrobromide, hydrochloride, hydroxynaphthoate, isethionate, lactate, lactobionate, malate, maleate, mandelate, mesylate, methylbromide, methylnitrate, methylsulfate, mucate, napsylate, nitrate, pamoate (embonate), pantothenate, phosphate/diphosphate, polygalacturonate, salicylate, stearate, subacetate, succinate, sulfate, tannate, tartrate, teoclate, triethiodide, benzathine, chlorprocaine, choline, diethanolamine, ethylenediamine, meglumine, procaine, aluminium, calcium, lithium, magnesium, potassium, sodium, and zinc. Examples of pharmaceutically unacceptable salts within the scope of the present invention include: hydroiodide, perchlorate, and tetrafluoroborate. Pharmaceutically unacceptable salts could be of use because of their advantageous physical and/or chemical properties, such as crystallinity.

Preferred pharmaceutically acceptable salts are the hydrochlorides, sulfates and bitartrates. The hydrochloride and sulfate salts are particularly preferred.

The term composition is intended to include the formulation of the active component with encapsulating material as a carrier providing a capsule in which the active component (with or without other carriers) is surrounded by a carrier which is thus in association with it. Similarly, cachets are included.

Tablets, powders, cachets, and capsules can be used as solid dosage forms suitable for oral administration.

Liquid from compositions include solutions, suspensions, and emulsions. Sterile water or water-propylene glycol solutions of the active compounds may be mentioned as an example

of liquid preparations suitable for parenteral administration. Liquid compositions can also be formulated in solution in aqueous polyethylene glycol solution.

Aqueous solutions for oral administration can be prepared by dissolving the active component in water and adding suitable colorants, flavoring agents, stabilizers, and thickening agents as desired. Aqueous suspensions for oral use can be made by dispersing the finely divided active component in water together with a viscous material such as natural synthetic gums, resins, methyl cellulose, sodium carboxymethyl cellulose, and other suspending agents known to the pharmaceutical formulation art.

Preferably the pharmaceutical compositions is in unit dosage form. In such form, the composition is divided into unit doses containing appropriate quantities of the active component. The unit dosage form can be a packaged preparation, the package containing discrete quantities of the preparations, for example, packeted tablets, capsules, and powders in vials or ampoules. The unit dosage form can also be a capsule, cachet, or tablet itself, or it can be the appropriate number of any of these packaged forms.

BIOLOGICAL EVALUATION

In vitro model

Cell culture

A. Human 293S cells expressing cloned human μ , δ , and κ receptors and neomycin resistance were grown in suspension at 37°C and 5% CO₂ in shaker flasks containing calcium-free DMEM10% FBS, 5% BCS, 0.1% Pluronic F-68, and 600 μ g/ml geneticin.

B. Mouse and rat brains were weighed and rinsed in ice-cold PBS (containing 2.5mM EDTA, pH 7.4). The brains were homogenized with a polytron for 15 sec (mouse) or 30 sec (rat) in ice-cold lysis buffer (50mM Tris, pH 7.0, 2.5mM EDTA, with phenylmethylsulfonyl fluoride added just prior use to 0.5mM from a 0.5M stock in DMSO:ethanol).

Membrane preparation

Cells were pelleted and resuspended in lysis buffer (50 mM Tris, pH 7.0, 2.5 mM EDTA, with PMSF added just prior to use to 0.1 mM from a 0.1 M stock in ethanol), incubated on ice for 15 min, then homogenized with a polytron for 30 sec. The suspension was spun at 1000g (max) for 10 min at 4°C. The supernatant was saved on ice and the pellets resuspended and spun as before. The supernatants from both spins were combined and spun at 46,000 g(max) for 30 min. The pellets were resuspended in cold Tris buffer (50 mM Tris/Cl, pH 7.0) and spun again. The final pellets were resuspended in membrane buffer (50 mM Tris, 0.32 M sucrose, pH 7.0). Aliquots (1 ml) in polypropylene tubes were frozen in dry ice/ethanol and stored at -70°C until use. The protein concentrations were determined by a modified Lowry assay with sodium dodecyl sulfate.

Binding assays

Membranes were thawed at 37°C, cooled on ice, passed 3 times through a 25-gauge needle, and diluted into binding buffer (50 mM Tris, 3 mM MgCl₂, 1 mg/ml BSA (Sigma A-7888), pH 7.4, which was stored at 4°C after filtration through a 0.22 µm filter, and to which had been freshly added 5 µg/ml aprotinin, 10 µM bestatin, 10 µM diprotin A, no DTT). Aliquots of 100 µl were added to iced 12x75 mm polypropylene tubes containing 100 µl of the appropriate radioligand and 100 µl of test compound at various concentrations. Total (TB) and nonspecific (NS) binding were determined in the absence and presence of 10 µM naloxone respectively. The tubes were vortexed and incubated at 25°C for 60-75 min, after which time the contents are rapidly vacuum-filtered and washed with about 12 ml/tube iced wash buffer (50 mM Tris, pH 7.0, 3 mM MgCl₂) through GF/B filters (Whatman) presoaked for at least 2h in 0.1% polyethyleneimine. The radioactivity (dpm) retained on the filters was measured with a beta counter after soaking the filters for at least 12h in minivials containing 6-7 ml scintillation fluid. If the assay is set up in 96-place deep well plates, the filtration is over 96-place PEI-soaked unifilters, which were washed with 3 x 1 ml wash buffer, and dried in an oven at 55°C for 2h. The filter plates were counted in a TopCount (Packard) after adding 50 µl MS-20 scintillation fluid/well.

Functional Assays

The agonist activity of the compounds is measured by determining the degree to which the compounds receptor complex activates the binding of GTP to G-proteins to which the receptors are coupled. In the GTP binding assay, GTP[γ]³⁵S is combined with test compounds and membranes from HEK-293S cells expressing the cloned human opioid receptors or from homogenised rat and mouse brain. Agonists stimulate GTP[γ]³⁵S binding in these membranes. The EC₅₀ and E_{max} values of compounds are determined from dose-response curves. Right shifts of the dose response curve by the delta antagonist naltrindole are performed to verify that agonist activity is mediated through delta receptors.

Procedure for rat brain GTP

Rat brain membranes are thawed at 37°C, passed 3 times through a 25-gauge blunt-end needle and diluted in the GTP γ S binding (50 mM Hepes, 20 mM NaOH, 100 mM NaCl, 1 mM EDTA, 5 mM MgCl₂, pH 7.4, Add fresh: 1 mM DTT, 0.1% BSA). 120 μ M GDP final is added membranes dilutions. The EC₅₀ and E_{max} of compounds are evaluated from 10-point dose-response curves done in 300 μ l with the appropriate amount of membrane protein (20 μ g/well) and 100000-130000 dpm of GTP γ ³⁵S per well (0.11 -0.14nM). The basal and maximal stimulated binding are determined in absence and presence of 3 μ M SNC-80

Data analysis

The specific binding (SB) was calculated as TB-NS, and the SB in the presence of various test compounds was expressed as percentage of control SB. Values of IC₅₀ and Hill coefficient (n_H) for ligands in displacing specifically bound radioligand were calculated from logit plots or curve fitting programs such as Ligand, GraphPad Prism, SigmaPlot, or ReceptorFit. Values of K_i were calculated from the Cheng-Prussoff equation. Mean \pm S.E.M. values of IC₅₀, K_i and n_H were reported for ligands tested in at least three displacement curves. Biological activity of the compounds of the present invention is indicated in Table 2.

Table 2: Biological data.

Ex. #	HDELTA (nM)			RAT BRAIN (nM)		MOUSE BRAIN (nM)	
	IC ₅₀	EC ₅₀	%EMax	EC ₅₀	%EMax	EC ₅₀	%EMax
1-11	0.50-13	0.32-104	94-106	2.9-867	125-159	4.9-1441	126-154

Receptor Saturation Experiments

5

Radioligand K_D values were determined by performing the binding assays on cell membranes with the appropriate radioligands at concentrations ranging from 0.2 to 5 times the estimated K_D (up to 10 times if amounts of radioligand required are feasible). The specific radioligand binding was expressed as pmole/mg membrane protein. Values of K_D and B_{max} from individual experiments were obtained from nonlinear fits of specifically bound (B) vs. nM free (F) radioligand from individual according to a one-site model.

10

Determination Of Mechano-Allodynia Using Von Frey Testing

15

Testing was performed between 08:00 and 16:00h using the method described by Chaplan et al. (1994). Rats were placed in Plexiglas cages on top of a wire mesh bottom which allowed access to the paw, and were left to habituate for 10-15 min. The area tested was the mid-plantar left hind paw, avoiding the less sensitive foot pads. The paw was touched with a series of 8 Von Frey hairs with logarithmically incremental stiffness (0.41, 0.69, 1.20, 2.04, 3.63, 5.50, 8.51, and 15.14 grams; Stoelting, Ill, USA). The von Frey hair was applied from underneath the mesh floor perpendicular to the plantar surface with sufficient force to cause a slight buckling against the paw, and held for approximately 6-8 seconds. A positive response was noted if the paw was sharply withdrawn. Flinching immediately upon removal of the hair was also considered a positive response. Ambulation was considered an ambiguous response, and in such cases the stimulus was repeated.

20

25

Testing Protocol

The animals were tested on postoperative day 1 for the FCA-treated group. The 50% withdrawal threshold was determined using the up-down method of Dixon (1980). Testing was started with the 2.04 g hair, in the middle of the series. Stimuli were always presented in a consecutive way, whether ascending or descending. In the absence of a paw withdrawal response to the initially selected hair, a stronger stimulus was presented; in the event of paw withdrawal, the next weaker stimulus was chosen. Optimal threshold calculation by this method requires 6 responses in the immediate vicinity of the 50% threshold, and counting of these 6 responses began when the first change in response occurred, e.g. the threshold was first crossed. In cases where thresholds fell outside the range of stimuli, values of 15.14 (normal sensitivity) or 0.41 (maximally allodynic) were respectively assigned. The resulting pattern of positive and negative responses was tabulated using the convention, X = no withdrawal; O = withdrawal, and the 50% withdrawal threshold was interpolated using the formula:

15

$$50\% \text{ g threshold} = 10^{(X_f + k\delta)} / 10,000$$

where X_f = value of the last von Frey hair used (log units); k = tabular value (from Chaplan et al. (1994)) for the pattern of positive / negative responses; and δ = mean difference between stimuli (log units). Here $\delta = 0.224$.

20

Von Frey thresholds were converted to percent of maximum possible effect (% MPE), according to Chaplan et al. 1994. The following equation was used to compute % MPE:

25

$$\% \text{ MPE} = \frac{\text{Drug treated threshold (g)} - \text{allodynia threshold (g)}}{\text{Control threshold (g)} - \text{allodynia threshold (g)}} \times 100$$

Administration Of Test Substance

Rats were injected (subcutaneously, intraperitoneally, intravenously or orally) with a test substance prior to von Frey testing, the time between administration of test compound and the von Frey test varied depending upon the nature of the test compound.

Writhing Test

Acetic acid will bring abdominal contractions when administered intraperitoneally in mice. These will then extend their body in a typical pattern. When analgesic drugs are administered, this described movement is less frequently observed and the drug selected as a potential good candidate.

A complete and typical Writhing reflex is considered only when the following elements are present: the animal is not in movement; the lower back is slightly depressed; the plantar aspect of *both* paws is observable. In this assay, compounds of the present invention demonstrate significant inhibition of writhing responses after oral dosing of 1-100 $\mu\text{mol/kg}$.

(i) Solutions preparation

Acetic acid (AcOH): 120 μL of Acetic Acid is added to 19.88 ml of distilled water in order to obtain a final volume of 20 ml with a final concentration of 0.6% AcOH. The solution is then mixed (vortex) and ready for injection.

Compound (drug): Each compound is prepared and dissolved in the most suitable vehicle according to standard procedures.

(ii) Solutions administration

The compound (drug) is administered orally, intraperitoneally (i.p.), subcutaneously (s.c.) or intravenously (i.v.) at 10 ml/kg (considering the average mice body weight) 20, 30 or 40 minutes (according to the class of compound and its characteristics) prior to testing. When the compound is delivered centrally: Intraventricularly (i.c.v.) or intrathecally (i.t.) a volume of 5 μL is administered.

The AcOH is administered intraperitoneally (i.p.) in two sites at 10 ml/kg (considering the average mice body weight) immediately prior to testing.

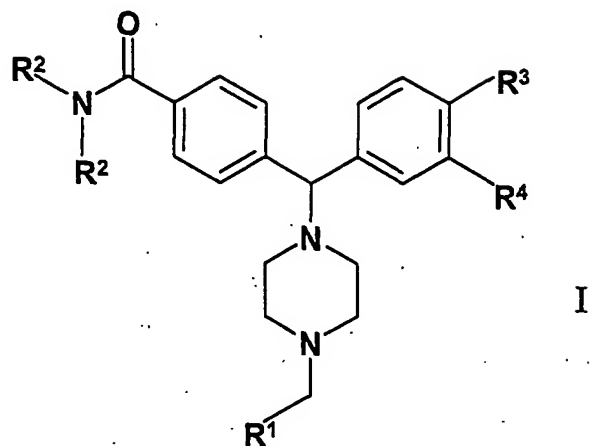
(iii) Testing

- 5 The animal (mouse) is observed for a period of 20 minutes and the number of occasions (Writhing reflex) noted and compiled at the end of the experiment. Mice are kept in individual "shoe box" cages with contact bedding. A total of 4 mice are usually observed at the same time: one control and three doses of drug.
- 10 For the anxiety and anxiety-like indications, efficacy has been established in the geller-seifter conflict test in the rat.

- For the functional gastrointestinal disorder indication, efficacy can be established in the assay described by Coutinho SV *et al*, in American Journal of Physiology - Gastrointestinal & Liver
- 15 Physiology. 282(2):G307-16, 2002 Feb, in the rat.

CLAIMS

1. A compound of the formula I



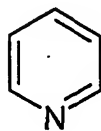
wherein

R^1 is selected from any one of

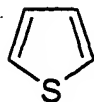
(i) phenyl;



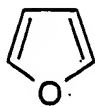
(ii) pyridinyl



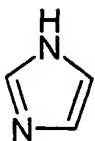
(iii) thienyl



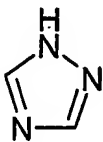
(iv) furanyl



5 (v) imidazolyl

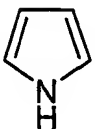


(vi) triazolyl

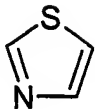


10

(vii) pyrrolyl

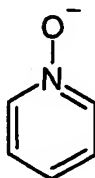


(viii) thiazolyl



15

(ix) pyridyl-N-oxide



wherein each R¹ heteroaromatic ring may optionally and independently be further substituted
20 by 1, 2 or 3 substituents selected from straight and branched C₁-C₆ alkyl, halogenated C₁-C₆ alkyl, NO₂, CF₃, C₁-C₆ alkoxy, chloro, fluoro, bromo, and iodo;

R² is independently selected from ethyl and isopropyl;

R³ is independently selected from hydrogen and fluoro;

5 R⁴ is independently selected from -OH, -NH₂ and -NHSO₂R⁵; and

R⁵ is independently selected from hydrogen, -CF₃ and C₁-C₆ alkyl,
or salts thereof or separate enantiomers and salts thereof,
provided that when R² is ethyl and R³ is hydrogen then R⁴ cannot be -OH.

10

2. A compound according to claim 1, wherein R¹ is phenyl, pyrrolyl, furanyl, thienyl or imidazolyl; R² is ethyl or isopropyl; R³ is hydrogen or fluoro; R⁴ is -NH₂ or -NHSO₂R⁵; and R⁵ is C₁-C₆ alkyl.

15

3. A compound according to claim 1, wherein R¹ is phenyl, pyrrolyl, furanyl, thienyl or imidazolyl; R² is ethyl or isopropyl; R³ is hydrogen; R⁴ is -NHSO₂R⁵; and R⁵ is C₁-C₆ alkyl.

4. A compound according to claim 1, wherein the heteroaromatic ring(s) are substituted by CF₃, methyl, iodo, bromo, fluoro or chloro.

20

5. A compound according to claim 1, wherein the heteroaromatic ring(s) are substituted by methyl.

6. A compound according to claim 1, selected from any one of

25

4-[1-(4-Benzyl-piperazin-1-yl)-1-(4-fluoro-3-hydroxy-phenyl)-methyl]-*N,N*-diisopropylbenzamide;

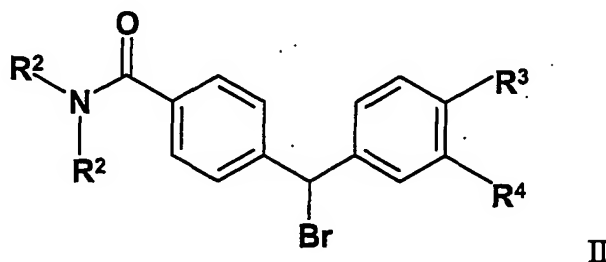
4-[1-(4-Fluoro-3-hydroxy-phenyl)-1-(4-thiophen-3-ylmethyl-piperazin-1-yl)-methyl]-*N,N*-diisopropylbenzamide;

30 4-{1-(4-Fluoro-3-hydroxy-phenyl)-1-[4-(1H-imidazol-2-ylmethyl)-piperazin-1-yl]-methyl}-*N,N*-diisopropylbenzamide;

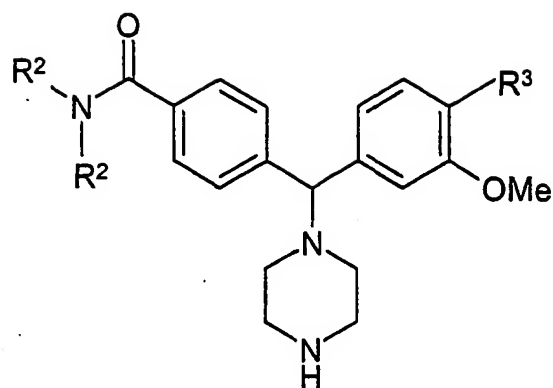
4-[1-(3-Amino-phenyl)-1-(4-benzyl-piperazin-1-yl)-methyl]-*N,N*-diisopropylbenzamide;

- 4-[1-(3-Amino-phenyl)-1-(4-thiophen-3-ylmethyl-piperazin-1-yl)-methyl]-*N,N*-diisopropylbenzamide;
- 4-{1-(3-Amino-phenyl)-1-[4-(1H-imidazol-2-ylmethyl)-piperazin-1-yl]-methyl}-*N,N*-diisopropylbenzamide;
- 5 *N,N*-Diisopropyl-4-[1-(3-methanesulfonylamino-phenyl)-1-(4-thiophen-3-ylmethyl-piperazin-1-yl)-methyl]-benzamide;
- 4-([4-(3-furylmethyl)-1-piperazinyl]{3-[(methylsulfonyl)amino]phenyl})-*N,N*-diisopropylbenzamide;
- 4-[(3-aminophenyl)[4-(3-thienylmethyl)-1-piperazinyl]methyl}-*N,N*-diethylbenzamide;
- 10 4-[(3-aminophenyl)(4-benzyl-1-piperazinyl)methyl]-*N,N*-diethylbenzamide, and
- 4-((4-benzyl-1-piperazinyl){3-[(methylsulfonyl)amino]phenyl}methyl)-*N,N*-diethylbenzamide.
7. A compound according to any of the preceding claims, in form of its hydrochloride,
- 15 dihydrochloride, sulfate, tartrate, ditrifluoroacetate or citrate salts.

8. A process for preparing a compound of formula I wherein R^4 is -OH, comprising reacting a compound of the general formula II



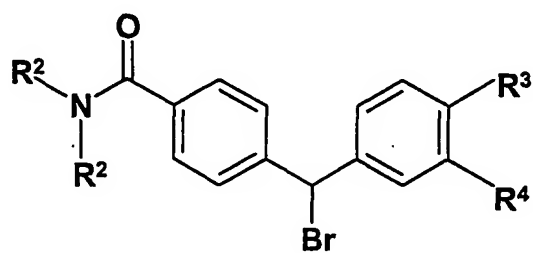
wherein R^2 and R^3 are as defined in claim 1 and R^4 is OMe, with Boc-piperazine in acetonitrile in the presence of triethylamine under standard conditions, followed by removal of the Boc protection group under standard conditions to give a compound of the Formula III



III

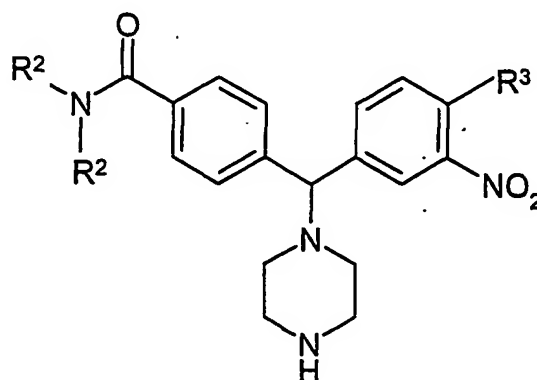
which is thereafter alkylated under reductive conditions with a compound of the Formula R^1 -CHO, followed by cleavage of the methyl ether using BBr_3 in dichloromethane to give a
 5 compound of the Formula I wherein R^4 is $-OH$.

9. A process for preparing a compound of formula I wherein R^4 is $-NH_2$, comprising reacting a compound of the general formula IV



IV

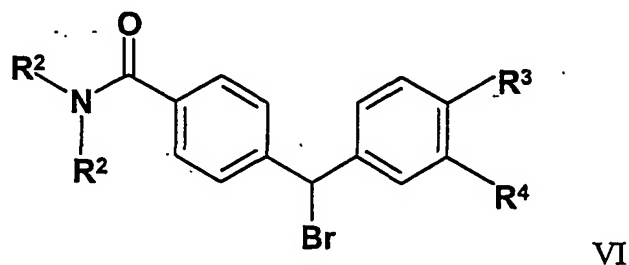
wherein R^2 and R^3 are as defined in claim 1 and R^4 is NO_2 , with Boc-piperazine in acetonitrile in the presence of triethylamine under standard conditions, followed by removal of the Boc protection group under standard conditions to give a compound of the Formula V



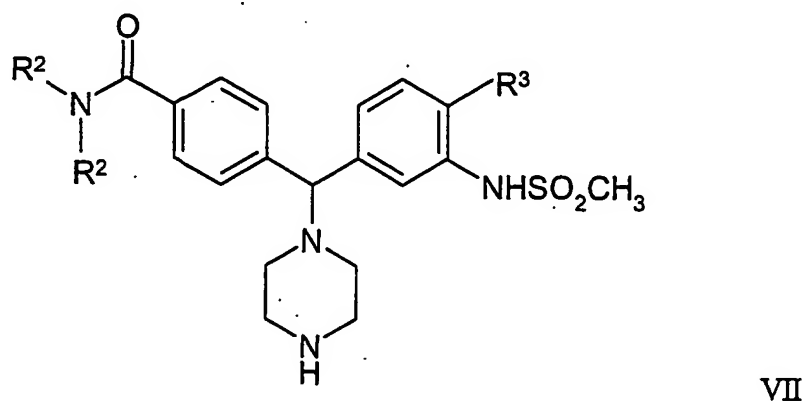
V

which is thereafter alkylated under reductive conditions with a compound of the Formula R^1 -CHO, followed by reduction of the nitro group using hydrogen and palladium on charcoal to give a compound of the Formula I wherein R^4 is $-NH_2$.

10. A process for preparing a compound of formula I wherein R^4 is $-NHSO_2R^5$, comprising reacting a compound of the general formula VI



wherein R^2 and R^3 are as defined in claim 1 and R^4 is NO_2 , with Boc-piperazine in acetonitrile in the presence of triethylamine under standard conditions, followed reduction of the nitro group by hydrogenolysis using palladium on charcoal as the catalyst, metanesulfonylation using methanesulphonylanhydride in dichloromethane in the presence of triethylamine, and thereafter removal of the Boc protection group under standard conditions to give a compound of the Formula VII



which is thereafter alkylated under reductive conditions with a compound of the Formula R^1 -CHO, followed by reduction of the nitro group using hydrogen and palladium on charcoal to give a compound of the Formula I wherein R^4 is $-NHSO_2R^5$.

11. A compound according to any of claims 1-7 for use in therapy.
12. Use of a compound according to formula I of claim 1 for the manufacture of a
5 medicament for use in the treatment of pain, anxiety of functional gastrointestinal disorders.
13. A pharmaceutical composition comprising a compound of the formula I according to claim 1 as an active ingredient, together with a pharmacologically and pharmaceutically acceptable carrier.
- 10 14. A method for the treatment of pain, whereby an effective amount of a compound of the formula I according to claim 1 is administered to a subject in need of pain management.
- 15 15. A method for the treatment of functional gastrointestinal disorders, whereby an effective amount of a compound of the formula I according to claim 1, is administered to a subject suffering from said functional gastrointestinal disorder.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 02/00956

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C07D 233/64, C07D 295/155, C07D 333/20, A61K 31/495, A61K 31/496,
A61P 25/04, A61K 25/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C07D, A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CHEM ABS DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9315062 A1 (THE WELLCOME FOUNDATION LIMITED), 5 August 1993 (05.08.93) --	1-15
PX	WO 0174805 A1 (ASTRAZENECA AB), 11 October 2001 (11.10.01) --	1-15
X	WO 9723466 A1 (ASTRA PHARMA INC. ET AL), 3 July 1997 (03.07.97) -- -----	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 Sept. 2002

Date of mailing of the international search report

18-09-2002

Name and mailing address of the ISA/

Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer

Solveig Gustavsson/MP
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE02/00956

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: **14-15**
because they relate to subject matter not required to be searched by this Authority, namely:
See extra sheet.
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

Claims 14-15 relate to methods of treatment of the human or animal body by surgery or by therapy/ diagnostic methods practised on the human or animal body/Rule 39.1.(iv). Nevertheless, a search has been executed for these claims. The search has been based on the alleged effects of the compounds/compositions.

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/09/02

International application No.

PCT/SE 02/00956

Patent document cited in search report				Publication date		Patent family member(s)	Publication date
WO	9315062	A1	05/08/93	AT	192197	T	15/05/00
				AU	675928	B	27/02/97
				AU	3457393	A	01/09/93
				CA	2129046	A	05/08/93
				DE	69230974	D,T	19/10/00
				EP	0649414	A	26/04/95
				EP	0650536	A,B	03/05/95
				GB	9202238	D	00/00/00
				IL	104582	A	30/10/98
				JP	3109832	B	20/11/00
				JP	7501583	T	16/02/95
				JP	7503247	T	06/04/95
				NZ	246916	A	27/08/96
				US	5492737	A	20/02/96
				US	5574159	A	12/11/96
				US	5658908	A	19/08/97
				US	5681830	A	28/10/97
				US	5854249	A	29/12/98
				US	2002052007	A	02/05/02
				ZA	9300717	A	02/08/94
WO	0174805	A1	11/10/01	AU	4498301	A	15/10/01
				AU	6031600	A	02/01/01
				SE	0001209	D	00/00/00
WO	9723466	A1	03/07/97	AU	715547	B	03/02/00
				AU	1216297	A	17/07/97
				BR	9612204	A	13/07/99
				CN	1209124	A	24/02/99
				CZ	9801768	A	16/09/98
				EE	9800194	A	15/12/98
				EP	0915855	A	19/05/99
				HU	9901304	A	30/08/99
				IL	124996	D	00/00/00
				JP	2000502679	T	07/03/00
				NO	310869	B	10/09/01
				NO	982807	A	19/08/98
				NZ	324887	A	28/01/00
				PL	327403	A	07/12/98
				SE	9504661	D	00/00/00
				SK	82298	A	04/11/98
				TR	9801180	T	00/00/00
				TW	458971	B	00/00/00
				US	6130222	A	10/10/00
				ZA	9610352	A	23/06/97